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BLACK NITE FLARE

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The Army and the Navy have and are using image intensifiers and low light level televisions (LLLTV). These items are used at all levels, that is, from individual soldier in the Army to part of the fire control directorate for the TARTAR missile system in the Navy. These electro-optical (EO) devices, however fail to perform adequately under 1/4 moon or less natural illumination conditions. over

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20. The EO image intensifiers and LLLTV devices which are now in or are soon to be in service utilize the S-1, improved S-20, or the S-25 photoemitter surfaces. Examination of these responses shows that the performance of the EO devices can be enhanced by visible and near infrared flux. Discussion of several compositions having peak emissions in the near infrared portion of the spectrum is included as well as reflectance data on natural terrain.

Testing of these compositions in the laboratory as well as in the field has been completed. Flare output data for the visible and infrared portion of the spectrum is included in the report.

Black Nite Flare

The services are using low light level televisions (LLLTV) tripod mounted image intensifiers, hand held and rifle mounted units, and goggle type devices. Image intensifiers are used at all authority levels and in all locations such as the B-52 bomber, the individual foot soldier and the TARTAR fire control system.

All image intensifiers rely on intensifying the image flux that is present to gain a usable image. Present day intensifiers do not perform adequately under one-quarter moonlight or less natural illumination conditions. Examination of the lunar cycle and cloud cover data reveals that in approximately 73% of the night hours you have one quarter moonlight or less natural illumination (1). To enhance the image produced by the intensifier and LLLTV, several techniques have been employed. These include: (a) use of visible illuminating flares; (b) use of spotlights filtered to remove the visible flux and transmit the near infrared flux; (c) use of laser illuminators; (d) use of a pyrotechnic flare having primarily near infrared emission (2).

Examine the disadvantages of the first three techniques of enhancement. Visible flares do enhance the performance of the system (3); however, they also allow all friendly and enemy forces to see. Drift of the visible flare can lead to exposure of friendly positions. Use of spotlights filtered to remove the visible flux is a technique used in the past, particularly on armored vehicles. This technique has one large drawback which is: if the enemy has night vision equipment, he can see exactly where the searchlight is and can direct his fire to destroy it and the carrying vehicle. The third technique of laser augmentation of the imaging system is presently being explored by at least the Navy and the Air Force. The major drawback is similar to the spotlight in that you give away your position when you activate your laser if the opposing forces have image intensifiers. An additional problem that is encountered is the need of pulse gating the systems such that the flux scattered in the laser beam in the intervening atmosphere between the source and the target being illuminated does not obscure the target.

The semi-convert near-infrared flare overcomes many of these problems; however, there are some drawbacks to using this type of flare also. Drawbacks to the infrared flare include having some visible candlepower and it is nearly impossible to deploy a flare without generating some acoustic signature.

To determine what types of near-infrared flares are desirable, examination of the spectral responsivity of the photoemitters is in order. Figure 1 is a plot of three of the more widely found surfaces in image intensifiers today. The S-1 photoemitter is found in the Metascope and many of the older devices and is usually used for visual tasks that are of short range. The S-20 surface was found in some of the older Starlight scopes. Newer Starlight scopes have an improved S-20 response which is closer to the S-25 response. The PVS-5 night goggles have a response closely approximated by that shown as the S-25 response.

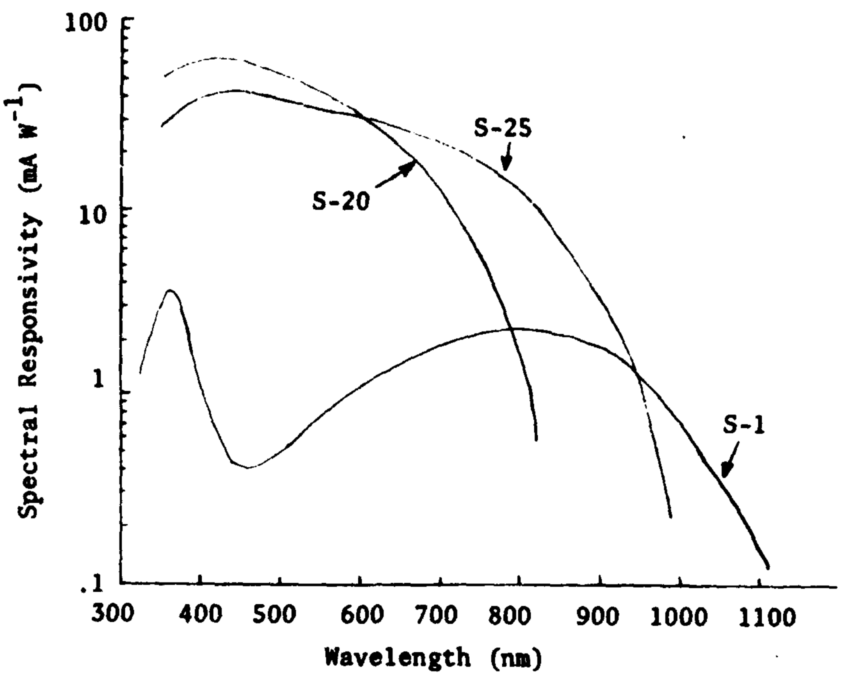

Figure 1. Visible and Near IR Photoemitter Characteristics.

With these responses in mind, we have obtained three types of compositions which have potential as sources. These compositions utilize alkali metal nitrates. They are potassium nitrate, rubidium nitrate and cesium nitrate. Figure 2 is the atomic line emission spectra (4) of the mentioned alkali metals.

Potassium having resonance line emission at .7698 and .7644 microns mates very well with the S-20 and S-25 responses shown in Figure 1, yet is just outside the visible spectrum which can be defined as .4 - .74 micron (y = .0001 at .760 micron). Broadening of these line emissions coupled with very limited eye response at .76 micron does give some visible flux. There is, of course, some flux in the visible due to other line emission and the temperature of the reaction.

In an attempt to reduce the visible emission and have the emission a bit farther in the infrared, rubidium nitrate was utilized as an oxidizer. The emissions near .79 micron mate reasonably well with the S-1 and S-25 curves. The general problem, however, is that there is a greater number of in-service image intensifiers having response properties between the S-20 and the S-25 curves than the S-25 to S-1 portion of the spectrum.

To obtain flux that is optimally compatible with the S-1 surface, cesium nitrate was utilized as an oxidizer in several flare formulations. Due to the temperature of the reaction, burn rates experienced in flare formulations, and atomic spectra, these flares had large IR power output; however, they also had greater visible flux emitted.

Typical formulations tested of all three types are shown in Table 1.

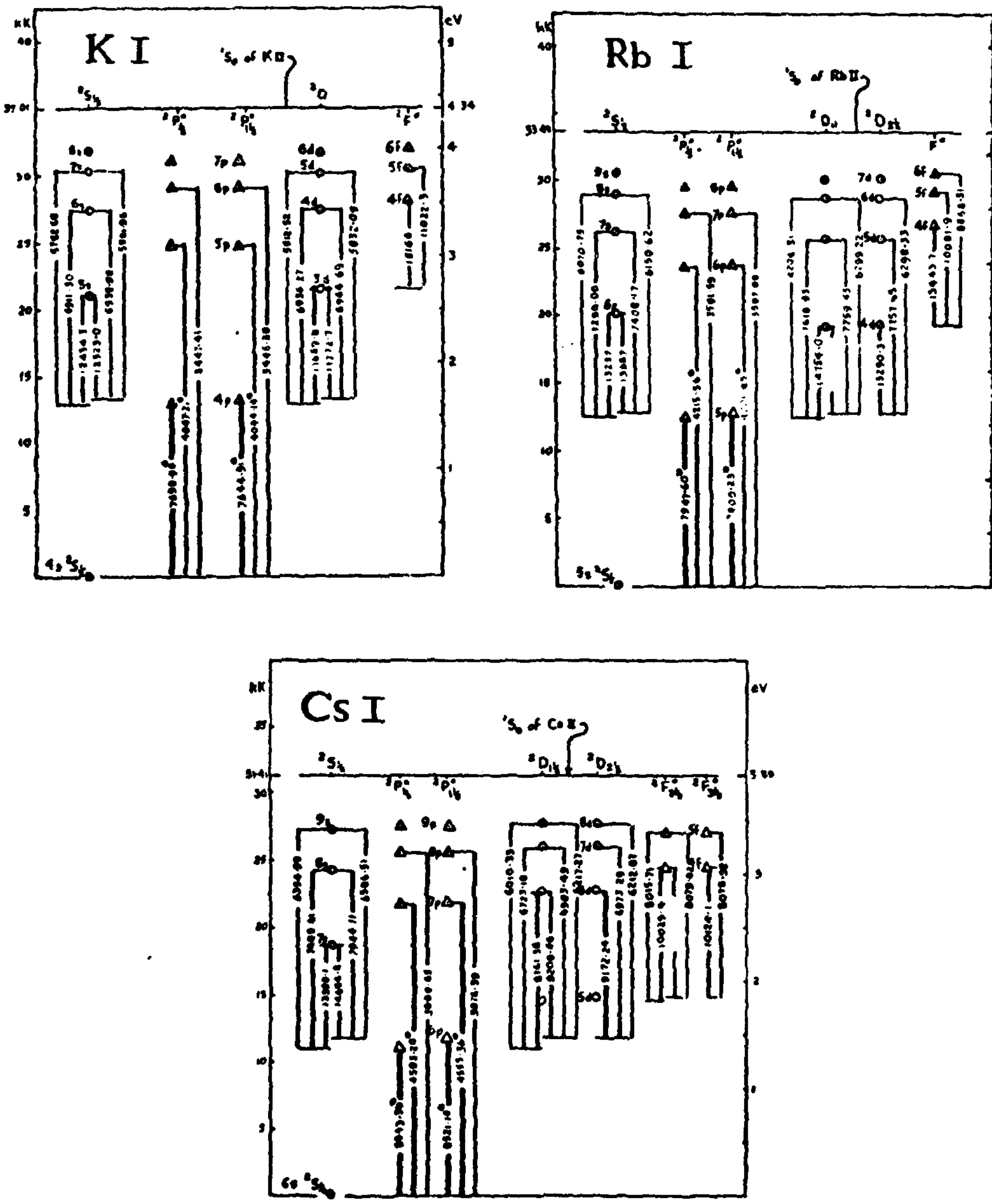

Figure 2. Atomic Spectra (taken from Candler)

Table I. Flare Formulas

	.76 Micron flare	.79 Micron flare	.8-.9 Micron flare
Silicon	10	10	16.3
Potassium nitrate	70		
Cesium nitrate			78.7
Rubidium nitrate		60.8	
Hexamethylenetetromine	16	23.2	
Epoxy resin (DER 321)	2.8	4.2	3.3
Epoxy hardener (DEH 14)	1.2	1.8	1.7

Flare candles composed of these compositions have been pressed into paper tubes having diameters from 1.6" to 4". Radiometric and spectra data on the potassium, which is the most interesting to NAVSEA and NAVAIR applications, have been taken. Table II contains a summary of data of primary interest to the design agents.

Table II. Flare Performance

	Watts/Steradian (.7-1 Micron)	Candlepower (.4-.74 Micron)	Burn rate (sec/in)
40 MM	14	65	45
MK 45 size (4.25")	160	900	45
*EX-18 size (3.375")	85	600	45
**155 MM size	80-100	600	40

* Candle composition pressed into the 5" EX-18 projectile paper.
** Pressed in steel containers that are used for the 155 MM illuminating load.

An interesting point noted during experimentation with the 40 MM size is that 20-30% of the visible flux originates from the burning of the paper tube on the flare candle. A large part of this flux is from the sodium impurity found in the paper. The spectral data taken on the near infrared flares shows that a predominant portion of the flux in the near infrared originates from the resonance lines. The visible emission is primarily composed of the gray body emission due to temperature and to the sodium impurity in the ingredients. A lesser amount of flux originates from the atomic lines in the visible spectrum.

One portion of the problems left unaddressed is that of the reflective properties of the elements in the natural scenario. Figures 3 and 4, although representing only a few materials formed in the battlefield, do indicate a general pattern. Most items are more reflective in the near infrared than in the visible.

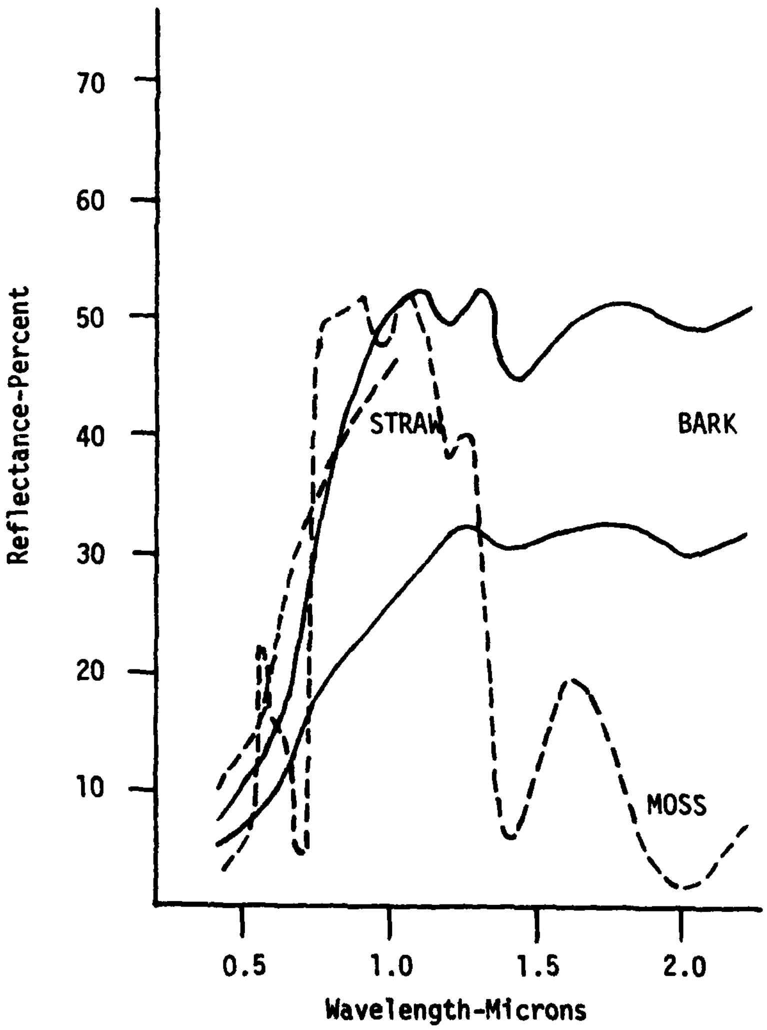

FIGURE 3

SPECTRAL REFLECTANCE OF TYPICAL EXAMPLES OF MOSS, TREE BARK, AND DRY STRAW

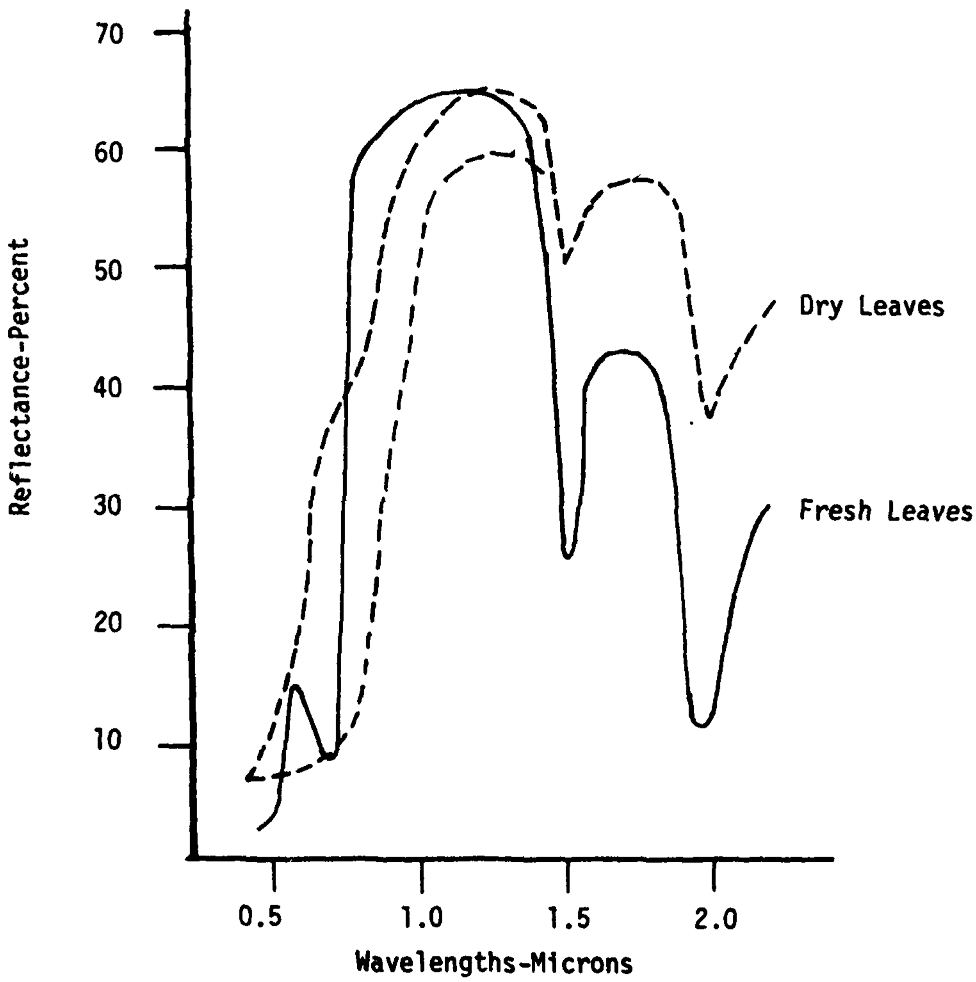

FIGURE 4

SPECTRAL REFLECTANCE OF TYPICAL LEAVES OF DECIDUOUS TREES

A video tape of the performance of image intensifiers under conditions of starlight, with visible flares and with near-infrared (EX-18 size) potassium flares, has been obtained. This tape, shown at the 5th International Pyrotechnic Seminar, demonstrates the vast improvement in target detection capability that can be obtained with the flares. The performance through the scope is comparable when utilizing visible and infrared flares. The visible flares fully illuminate, to the naked eye, everyone in the total test area while only those having night vision devices were capable of utilizing the flux from the IR flares.

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